

4.0 GROUND WATER INVESTIGATIONS

1. The purpose of this chapter is to summarize the prior and recent ground water investigations at the former ILM facility. The initial ground water investigations began in August 1994 and were completed concurrent with the soil RFI, prior to the preparation of the Ground Water RFI Workplan (*Groundwater RCRA Facility Investigation Workplan*, January 19, 1996 [Geraghty & Miller, 1996c]). Ground water investigations continued through November 1999.

4.1 PRIOR INVESTIGATIONS

1. A summary of the prior ground water investigations is provided below:
 - 1994
 - Installation of five ground water monitoring wells as part of soil RFI activities.
 - 1995
 - Installation of five additional ground water monitoring wells in March.
 - March 1995 ground water sampling.
 - Installation of 16 additional ground water monitoring wells and December 1995 ground water sampling of 25 wells.
 - 1996
 - Second, third and fourth quarter ground water sampling.
 - GWRFI workplan.
 - Ground water data assessment report.
 - 1997
 - July 1997 ground water sampling.
 - Abandonment of ten ground water wells.
 - 1998
 - Ground water investigation workplan for BRC property offsite wells.
 - Corrective Action Consent Agreement for ground water.
 - 1999
 - Ground water sampling workplan for former ILM facility onsite and BRC property offsite wells.
 - GWRFI workplan update.
 - March 1999 offsite well installation and ground water monitoring.

These investigations are summarized in the following sections. Summaries of the well construction details, ground water elevation data and ground water analytical data are provided in Tables 4.1 through 4.15. Locations of existing and abandoned HydroPunch™ and ground water monitoring wells on the former ILM facility and BRC property are shown in Figure 4.1. Boring logs are provided in Appendix B.

4.1.1 SOIL RCRA FACILITY INVESTIGATION (SRFI)

1. The Soil RCRA Facility Investigation (SRFI) included some initial ground water investigation activities. These activities are documented in the February 26, 1996 SRFI report, a May 1996 draft data assessment report, and three quarterly 1996 monitoring reports, and are summarized in the following sections.

4.1.1.1 Piezometer Installation Program (Ground Water Monitoring Wells P-1 Through P-10)

1. The primary objective of the Piezometer Installation Program at the site was to drill and install five piezometers (P-1 through P-5) in order to assess ground water gradient and direction of flow. These five piezometers were the first ground water wells ever installed at the site. The data collected from the piezometers was used to assist in the design and placement of additional piezometers. During August 15 through 19, 1994, Piezometers P-1, P-2, P-3, P-4 and P-5 were drilled and installed at the site. Piezometer P-1 was installed to the south of the former tow-motor shop; P-2 was installed adjacent to the former solvent still-house; P-3 was installed in the northwest corner of the property; P-4 was installed in the former boring mill area; and P-5 was installed in the former foundry storage area.
2. Based on the findings of the P-1 through P-5 Piezometer Installation Program, five additional piezometers (P-6 through P-10) were installed at the site in March 1995.
3. The *Piezometer Installation Program Report*, Light Metals Division Facility, December 15, 1994 (Geraghty & Miller, 1994) documented the installation of piezometers P-1 through P-5. The installation of piezometers P-6 through P-10 is documented in the SRFI Report (Geraghty & Miller, 1996a).

4.1.1.2 January and March 1995 Ground Water Sampling

1. The January 1995 ground water sampling included the initial five permanent ground water monitoring wells (P-1 through P-5). The March 1995 ground water sampling included the additional five permanent ground water monitoring wells (P-6 through P-10) and eight HydroPunch™ borings (RB-59, RB-62, RB-64, RB-130, RB-132, RB-145, RB-150 and RB-153). (For information on the HydroPunch™ installations, see Soil Boring Summary from the SRFI [Geraghty & Miller, 1996a] in Appendix C.)

2. Ground water samples were analyzed for VOCs, SVOCs, TPHs, metals, PCBs and dioxins/furans. TPH constituents in shallow ground water were predominantly in the diesel range and occurred near the northeast corner of the site. A total of 16 VOCs and five SVOCs were detected in ground water samples collected from the site. The three most prevalent chlorinated VOCs included TCE, 1,1-DCE and PCE. Pentachlorophenol (PCP) was the only SVOC which exceeded an MCL. Dioxins/furans were also detected. However, the most toxic dioxin/furan (2,3,7,8-TCDD) was not detected in ground water samples at the site. The MCLs for total metals were exceeded for chromium, aluminum, arsenic, barium, nickel and cadmium.

4.1.1.3 Installation of 16 Additional Ground Water Monitoring Wells

1. During November and December 1995, 16 additional ground water monitoring wells (P-11 through P-15, P-16A, P-16B and P-17 through P-25) were installed at the site. In addition, the quarterly ground water monitoring (for one year) was initiated with the December 1995 ground water sampling event.
2. Ground water samples were analyzed for VOCs, SVOCs, TPHs, metals, PCBs and dioxins/furans. The December 1995 sampling confirmed the findings of the March 1995 sampling event and further defined the extent of the impacted ground water. A total of 16 VOCs (benzene, bromodichloromethane, bromoform, chloroform, cis- and trans-1,2-DCE, dibromochloromethane, 1,1-DCA, 1,1-DCE, 1,2-dichloropropane, ethylbenzene, PCE, TCE, 1,1,1-TCA, toluene and xylenes) were detected in 24 wells (Wells P-1, P-2, P-3, P-4, P-5, P-6, P-7, P-9, P-11, P-12, P-13, P-14, P-15, P-16A, P-16B, P-17, P-18, P-19, P-20, P-21, P-22, P-23, P-24 and P-25). A total of eight SVOCs (benzyl alcohol, bis-2-ethylhexyl-phthalate, 2-methylnaphthalene, naphthalene, phenol, acenaphthene, phenanthrene and fluorene) were detected in 11 wells (P-4, P-5, P-6, P-7, P-9, P-10, P-11, P-16B, P-17, P-21 and P-24). TPHs were detected in nine wells (Wells P-2, P-5, P-16A, P-16B, P-17, P-19, P-22, P-24 and P-25). Aluminum and chromium were found to exceed their respective MCLs in 23 and 12 wells, respectively. PCBs were not detected during the December 1995 sampling. Nine dioxin/furan compounds (1,2,3,4,6,7,8,9-OCDD, 1,2,3,4,6,7,8-HpCDD, total hepta-CDDs, total hepta-CDFs, total hexa-CDFs, 1,2,3,4,6,7,8,9-OCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8-HxCDF, and 1,2,3,7,8,9-HxCDF) were detected at low concentrations in eight wells (P-1, P-2, P-7, P-10, P-11, P-12, P-16A and P-19).

3. The analytical results for VOCs, TPHs, and metals are summarized in Tables 4.6, 4.8 and 4.10. The analytical results for SVOCs, PCBs, and dioxins/furans are included in Appendix D.

4.1.1.4 Second, Third, and Fourth Quarter 1996 Ground Water Sampling

1. The quarterly ground water sampling events consisted of measuring water levels and purging and sampling ground water monitoring wells P-1 through P-25. Ground water samples were submitted for TPHs, VOCs, SVOCs, metals, PCBs, and dioxins/furans chemical analysis. In addition, samples were analyzed for 21 inorganic water chemistry parameters.
2. Each of these sampling events was documented in a quarterly ground water monitoring report:
 - *Second Quarterly Groundwater Monitoring Report (First Quarter 1996)*, RCRA Facility Investigation, Lockheed Martin Corporation, International Light Metals Facility, Torrance, California, August 30, 1996, Geraghty & Miller, Inc. (Geraghty & Miller, 1996d);
 - *Third Quarterly Groundwater Monitoring Report (Second Quarter 1996)*, RCRA Facility Investigation, Lockheed Martin Corporation, International Light Metals Facility, Torrance, California, October 2, 1996, Geraghty & Miller, Inc. (Geraghty & Miller, 1996e);
 - *Fourth Quarterly Groundwater Monitoring Report (Third Quarter 1996)*, RCRA Facility Investigation, Lockheed Martin Corporation, International Light Metals Facility, Torrance, California, December 24, 1996, Geraghty & Miller, Inc. (Geraghty & Miller, 1996g).

The reports include ground water gradient and flow direction data, field methodologies, a discussion of results and a quality assurance/quality control (QA/QC) evaluation.

3. The ground water gradient and flow direction remained relatively unchanged throughout 1996. Hydrographs indicate that from August 1994 to June 1996, ground water levels have trended slightly upward in all the wells onsite. Hydrographs for each onsite well are included in Appendix E.
4. Analytical results for the ground water samples are relatively consistent from quarter to quarter and with previous sampling events. Constituent concentrations remained about the same or trended downward in some wells. Significant constituents of concern (COC) included select chlorinated hydrocarbons (e.g., TCE, PCE, and 1,1-DCE) and metals (e.g., chromium).

5. The analytical results for VOCs, TPHs and metals are summarized in Tables 4.6, 4.8 and 4.10. The analytical results for SVOCs, PCBs and dioxins/furans are included in Appendix D.
6. A total of nine SVOCs (benzyl alcohol, bis-2-ethylhexyl-phthalate, di-n-octylphthalate, fluorene, 2-methyl naphthalene, 4-methyl-phenol, naphthalene, phenanthrene, and phenol) were detected in 18 wells (P-4, P-5, P-6, P-7, P-9, P-10, P-12, P-13, P-15, P-16A, P-16B, P-16C, P-17, P-18, P-20, P-22, P-23, and P-24). PCB-1254 was the only PCB congener detected during the 1996 ground water sampling events and was observed in two wells (Wells P-1 and P-2). The presence of the SVOCs and PCBs in the ground water may be related to historical operations of the former secondary aluminum foundry, impacts from undefined offsite, upgradient sources, or cross contamination of ground water during well construction and/or sample collection.
7. A total of 17 dioxin/furan congeners (1,2,3,4,6,7,8,9-OCDD, 1,2,3,4,6,7,8,9-OCDF, 1,2,3,4,6,7,8-HpCDD, 1,2,3,4,5,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, 1,2,3,4,7,8-HxCDD, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDD, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDD, 1,2,3,7,8,9-HxCDF, 1,2,3,7,8-PeCDD, 1,2,3,7,8-PeCDF, 2,3,4,6,7,8-HxCDF, 2,3,4,7,8-PECDF, 2,3,7,8-TCDD, and 2,3,7,8-TCDF, and eight undifferentiated dioxin/furan compounds (total hepta CDDs, total hepta CDFs, total hexa CDDs, total hexa CDFs, total penta CDDs, total penta CDFs, total tetra CDDs, and total tetra CDFs) were detected. The presence of dioxin/furan congeners in ground water may also be related to historical operations of the former secondary aluminum foundry, impacts from undefined offsite, upgradient sources, or cross contamination of ground water during well construction and/or sample collection.
8. Individual dioxin/furan congeners were observed at low concentrations in ground water samples obtained from nine wells (P-2, P-4, P-5, P-6, P-18, P-19, P-21, P-24, and P-25) sampled between December 1995 (fourth quarter 1995) and March 1996 (first quarter 1996). The highest concentrations of dioxin/furan compounds were observed in ground water samples obtained from Well P-2 located on the northwest (upgradient) portion of the site. As of September 1996 (third quarter 1996), the sum of the dioxin/furan congeners detected in ground water from Well P-2 and expressed as toxicity equivalents (TEQ) of

2,3,7,8-TCDD (the dioxin of most concern) was 47 picograms per liter (pg/L). The dioxin 2,3,7,8-TCDD, however, was not detected in Well P-2 (e.g., less than 14 pg/L). The MCL for 2,3,7,8-TCDD is 30 pg/L.

9. Given the low concentrations of SVOCs, PCBs and dioxin/furan congeners observed in ground water at the site, along with their high adsorption/retardation factors and low mobility, subsequent analyses for these compounds in ground water was not performed after the September 1996 sampling event.

4.1.2 GROUND WATER RFI ACTIVITIES

1. In response to the findings of the initial ground water investigations at the site, a Ground Water RFI was initiated. A summary of the GWRFI activities is provided in this section.

4.1.2.1 Groundwater RFI Workplan

1. The GWRFI was initiated in December 1995 by ARCADIS G&M, Inc. A GWRFI Workplan (GWRFI Workplan [Geraghty & Miller, 1996c]) was submitted to DTSC in January 1996. This workplan specified the activities to be conducted under the GWRFI, and included a site-specific Quality Assurance Project Plan (QAPP), a Project Management Plan (PMP), a Data Management Plan (DMP), and a Sampling and Analysis Plan (SAP).
2. The purpose and objectives of the GWRFI at the former ILM facility are to acquire, analyze and interpret ground water data that accomplish the following:
 - Determine the nature and extent of releases to the ground water of hazardous waste or constituents from regulated units, SWMUs and other AOCs at the former ILM facility.
 - Gather necessary data to support the Corrective Measures Study, if required.
3. In developing the GWRFI Workplan, a strategy based on a phased approach was formulated. The phased approach allowed data from each phase to be evaluated and incorporated into the next phase, allowing refinement and, if necessary, additions to and/or modifications of the proposed scope in order to effectively achieve the objectives of the GWRFI. This phased approach is summarized below.

Phase I - Stratigraphic Correlation of Geology Beneath ILM Facility to Regional Hydrostratigraphic Model (This work was performed during the SRFI activities.)

1. The initial phase of the GWRFI involved the drilling and sampling of two deep borings in the southwest and northeast corners of the property. The data collected from the borings was utilized for correlating the stratigraphy beneath the former ILM facility to the regional stratigraphy of the area.
2. Existing hydrogeologic data collected from investigations performed offsite by ARCADIS G&M was reviewed and interpreted to aid in the correlation of the site data to the regional hydrostratigraphic model. Other activities in Phase I of the GWRFI included continued collection of monthly depth-to-ground water measurements in the existing onsite wells.

Phase II - Investigation of Releases to Ground Water/Migration in First Encountered Ground Water (This work was performed during the SRFI activities.)

1. The data generated in Phase I was evaluated, along with all other available information, in order to finalize the strategy for the installation of 16 additional ground water monitoring wells. The monitoring wells were installed in the ground water first encountered on the facility property. Subsequent to well installation and development, all onsite wells were sampled, the data evaluated, and a draft data assessment report was submitted to the DTSC. The data assessment report summarized the methodologies and findings, provided data evaluation, and made recommendations for further work to adequately characterize ground water quality beneath the facility.

Phase III - Additional Ground Water Characterization (This work was performed during the SRFI activities.)

1. Phase III focused on the following tasks: (1) preparation and implementation of a Supplemental GWRFI Workplan to provide for collection of additional data needed to complete the characterization of onsite ground water quality; (2) acquisition of ground water data such as direction and rate of flow, and physical aquifer parameters such as hydraulic conductivity and effective porosity; and (3) investigation of seasonal and temporal variations on ground water flow and quality. Tasks 2 and 3 were accomplished through three additional quarterly ground water monitoring and sampling events. The scope of work for Phase III was formulated from information collected and interpreted from the first two phases.

Phase IV - Data Evaluation and Reporting

1. Based on data gathered from Phases I through III, an evaluation of the need for additional work (i.e., installation of additional monitoring wells/borings, additional quarterly ground water monitoring, and water level measurements) was made. The additional work included performance of another round of ground water monitoring and sampling, installation of offsite ground water monitoring wells and performance of two additional rounds of ground water monitoring and sampling of remaining onsite and new offsite wells.

4.1.2.2 Groundwater Data Assessment Report (DAR)

1. The *Draft Groundwater Data Assessment Report*, Lockheed Martin Corporation, International Light Metals Facility, Torrance, California, 1996, Geraghty & Miller, Inc. (Geraghty & Miller, 1996f) summarized the methodologies and findings, provided data evaluation, and made recommendations for further work to adequately characterize ground water quality beneath the facility.
2. The DAR indicated the COCs included fuel hydrocarbons, aromatic and chlorinated hydrocarbons, lubrication and other heavy oils, and metals. COCs for which ground water plumes were identified included VOCs and chromium.
3. The DAR indicated the potential sources for chromium in ground water at the former ILM facility included a drywell (near Well P-1/P-15), and cooling towers and associated drainage pit and sumps where chromium was used as a corrosion inhibitor (near Well P-14). (The presence of chromium in ground water in other areas of the facility may be associated with other former cooling tower locations and the use of chromium in former plating and etching operations.)
4. TCE was found in ground water along the northern property boundary (near Well P-12) and appeared to be associated with a clarifier for chip wringing effluent and oil reclamation area. In the eastern-central portion of the site (near Well P-25), the TCE sources appeared to be a titanium chip processing area and solvent AST; a neutralization UST and overflow sump; a precision forge process area, including a clarifier converted to oily water storage; a sump pit, a three-tank etch unit, and a five-tank forge etch unit; a dry well; and three drainage sumps in the hazardous waste storage yard. There was not an onsite TCE source associated with the ground water plume located along the central western property boundary (near Well P-9). The ground water impact areas for PCE and 1,1-DCE coincided in the eastern-central site area

(near Well P-25). Potential sources for this impact were also the same for both PCE and 1,1-DCE: the titanium chip processing area and solvent AST (also potential sources of TCE, as discussed above).

5. TPH-d was found beneath the site along the western property boundary (near Well P-2) and appeared to be associated with the solvent still house area; specifically the solvent transfer pipeline. The TPH-d impacts in the ground water near the north end of the eastern property boundary (near Well P-5) appeared to be associated with two former steel USTs which were used for the storage of diesel fuel. In the eastern-central site area (near Well P-25), TPH-d ground water impacts appeared to be associated with the titanium chip processing area and solvent AST (also potential sources of TCE and PCE, as discussed above). TPH-k was also identified in ground water along the western property boundary (near Well P-2). The source for TPH-k is potentially the same as that for TPH-d; the solvent transfer pipeline and the still house (Geraghty & Miller, 1996f).

4.1.2.3 Additional Ground Water Investigation Activities

4.1.2.3.1 July 1997 Sampling Event

1. The July 1997 gauging and sampling were completed to provide updated information on ground water conditions beneath the former ILM facility. The July 1997 monitoring event involved purging and sampling the 25 onsite wells and submittal of the samples to BC Laboratories, Inc. for chemical analysis.
2. Consistent with previous sampling events, metals, VOCs and hydrocarbons were detected in the ground water samples.
3. The July 1997 sampling event was documented in a *Groundwater Monitoring Report, July 1997* dated October 24, 1997 (Geraghty & Miller, 1997a). Ground water elevation data, quality parameters, and analytical results are included in Tables 4.2, 4.4, 4.6, 4.8, 4.10 and 4.12.

4.1.2.3.2 Well Abandonments

1. In 1997, ten wells (Wells P-4, P-11, P-13, P-14, P-15, P-18, P-19, P-21, P-23 and P-25) were abandoned in order to facilitate building construction for the new property owner.

4.1.2.4 Offsite Ground Water Characterization Workplan

1. In March 1998, Integrated Environmental Services, Inc. (IES) prepared a workplan, *Offsite Ground Water Characterization Workplan LMC*, Former ILM Facility, March 1988 (IES, 1988), for the offsite characterization of ground water to the east of the former ILM site. The objective of the investigation was to develop sufficient information to make informed decisions regarding the nature and extent of ground water impacts associated with constituents of concern from the former ILM facility site migrating onto the BRC property to the east.
2. The workplan outlined the data quality objectives, sampling rationale, sampling and analysis plan, reporting and schedule. The workplan was implemented by IES and the results were reported in the *March 1999 Groundwater Monitoring and Offsite Well Installation Report* dated May 19, 1999 by ARCADIS G&M (ARCADIS G&M, 1999b).

4.1.2.5 Ground Water Corrective Action Consent Agreement

1. A Corrective Action Consent Agreement (Consent Agreement) regarding ground water issues at the site was executed on December 28, 1998 by the DTSC and LMC. The Consent Agreement specifies the terms under which issues relating to ground water impacts beneath the site and migrating offsite will be resolved. This GWRFI Report is a requirement under Attachment D of the Consent Agreement. All work to be conducted under the GWRFI was conducted according to the GWRFI Workplan, updates to the workplan and the Consent Agreement.

4.1.2.6 Ground Water RFI Workplan Update

1. In March 1999, the GWRFI Workplan was updated. The updated GWRFI Workplan (*Groundwater RFI Workplan*, International Light Metals Facility, March 15, 1999 [ARCADIS G&M, 1999d]) included a site-specific Project Management Plan and a revised Health and Safety Plan and Quality Assurance Project Plan (QAPP). In addition, the updated GWRFI included a revised schedule.

4.1.2.7 March 1999 Ground Water Sampling Scope of Work

1. The GWRFI Workplan Update also contained the scope of work utilized during the March 1999 ground water sampling event. The scope of work included information on the number of wells sampled and the laboratory analyses to be performed.

4.1.2.8 March 1999 Groundwater Monitoring and Offsite Well Installation Report

1. The purpose of the March 1999 ground water monitoring and offsite well installation work was to provide updated information on ground water conditions beneath and east of (downgradient from) the former ILM facility. The results of the ground water gauging and sampling were compared with previous ground water gauging and sampling results (Geraghty & Miller, 1996d,e and g, and 1997a) to identify variations in the nature of contamination in ground water in this area. The new information obtained at the BRC property was used to characterize the nature of ground water contamination east of (downgradient from) the former ILM facility, beneath the BRC property.
2. The March 1999 sampling consisted of sampling 14 ground water wells at the former ILM facility and eight ground water monitoring wells at the BRC property to the east. A sample was not collected from Well P-5 because a petroleum hydrocarbon sheen was detected in the well during water-level measurement activities (ARCADIS G&M, 1999b).
3. As with previous sampling events, VOCs, TPHs and metals were detected in the ground water samples collected. Ground water elevation data, quality parameters, and analytical results for the March 1999 sampling event are included in Tables 4.2 through 4.13.
4. In the ground water samples collected at the former ILM facility, 12 VOCs were detected above their practical quantitation limits (PQLs), with TCE the most frequently detected and at the highest in concentration. At the BRC property, VOCs were detected above their PQLs in the eight wells sampled, with TCE again the most frequently detected and at the highest in concentration. Other VOCs detected included 1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,2-DCE (cis- and trans-), 1,2-dichloropropane, chloroform, benzene and toluene.
5. TPHs were detected in Wells P-2, P-6B, P-7, P-10, P-16A and P-24 at the former ILM facility. TPH was also previously detected in ground water samples collected from Well P-5, but ground water from this well was not sampled in March 1999 due to the presence of a

petroleum hydrocarbon sheen detected during water-level measurement activities. At the BRC property, TPH was detected in Wells BL-1 and -5, which are near the former ILM facility Well P-5.

6. At the former ILM facility and BRC property, aluminum, lead, and hexavalent chromium were detected in the March 1999 ground water samples at concentrations considered above site background levels. Distribution patterns of aluminum in ground water may be closely related to background concentrations of metals in soil (ARCADIS G&M, 1999b).

4.2 JULY 1999 GROUND WATER SAMPLING ACTIVITIES

1. This section provides a summary of the July 1999 ground water sampling methodology and results.

4.2.1 WORKPLAN FOR JULY 1999 GROUND WATER MONITORING

1. The scope of work for the July 1999 ground water sampling was performed pursuant to the GWRFI Workplan and update (Geraghty & Miller, 1996c & ARCADIS G&M, 1999d) and RFI Workplan Addendum letter (dated June 21, 1999 [ARCADIS G&M, 1999e]).

4.2.2 GROUND WATER SAMPLING

1. The following sections describe the methods used during the ground water gauging and sampling performed by ARCADIS G&M.

4.2.2.1 General Sampling Methods

1. The investigation methodology utilized during ground water gauging and sampling was in accordance with standard industry practice. Standard Operating Procedures (SOPs) for methods used in the investigation are included in Attachment B of the GWRFI QAPP, which is Appendix D of the GWRFI Workplan (Geraghty & Miller, 1996c) and updated in the GWRFI Workplan of March 15, 1999 and the letter dated June 21, 1999 (ARCADIS G&M, 1999d and 1999e). Ground water sampling methods were also described in Section 6.0 of the GWRFI Workplan (Geraghty & Miller, 1996c).

4.2.2.1.1 Gauging

1. Depth-to-water measurements were collected from 15 wells on the former ILM facility site and eight wells on the BRC property according to procedures set forth in the workplans.
2. Depth to water and total well depth measurements were performed and recorded using a Solinst electronic water interface probe. At Well P-5, where a petroleum hydrocarbon sheen has been identified on the ground water surface in prior monitoring events, an Oil Recovery System (ORS) interface probe was used. Measurements were collected relative to a standard measuring point, which for each well is the north side of the top of the well casing. This measuring point has been surveyed relative to mean sea level, allowing calculation of ground water elevation from the depth measurements. A measurable thickness of floating hydrocarbon has not been detected in Well P-5.

4.2.2.1.2 Purging and Sampling

1. Prior to sampling and following collection of a complete set of depth-to-water measurements as described above, each well to be sampled was purged of a minimum of four well-casing volumes. Wells which are slotted in a low permeability zone, however, were purged dry once. Purging procedures were conducted as described in Section 4.8.1 of the QAPP and according to SOP No. 9 in Attachment B of the QAPP and update (Geraghty & Miller, 1996c [Appendix D] and ARCADIS G&M 1999d). These procedures also describe the collection of field data from each well, including pH, temperature, conductivity, and turbidity.
2. Ground water samples were collected from each well (with the exception of P-5, where a petroleum hydrocarbon sheen was detected in the well during gauging) after the wells were allowed to recover to at least 80 percent of the original water column. The collection of ground water samples was conducted as described in Sections 4.8, 4.9, 4.10, and 5.0 of the QAPP, and in SOP No. 10 in Attachment B of the QAPP and update (Geraghty & Miller, 1996c [Appendix D] and ARCADIS G&M 1999d).

4.2.2.1.3 Sample Handling

1. To preserve sample integrity, all samples submitted for laboratory analysis were tracked according to standard chain-of-custody protocols and were handled according

to standard industry practices. Sample handling and custody methods are discussed in detail in Sections 4.11, 4.13, and 5.0 of the QAPP and update (Geraghty & Miller, 1996c [Appendix D] and ARCADIS G&M, 1999d).

4.2.2.1.4 Analytical Methodology

1. Chemical analysis of samples collected during ground water monitoring was performed by BC Laboratories according to protocols discussed in the GWRFI workplans (Geraghty & Miller, 1996c and ARCADIS G&M, 1999d and 1999e). Ground water samples were analyzed for the chemical analytes listed below. The results of these analyses are discussed in Section 4.2.3 of this report. The analyses were conducted according to the methodology discussed in Section 7.2 of the QAPP and update, and workplans (Geraghty & Miller, 1996c [Appendix D], and ARCADIS G&M, 1999d and 1999e). Analyses of ground water samples were conducted according to the appropriate workplan using the following methods:

- Total petroleum hydrocarbons fuel fingerprint by United States Environmental Protection Agency (EPA) Method 8015M (as modified in the California Department of Health Services LUFT Manual); analytes include stoddard/white spirits, JP4, JP5, JP6, JP8, kerosene/jet fuel, diesel, crude oil, waste oil, and motor oil.
- Volatile organic compounds (VOCs) by EPA Method 8260.
- Total and dissolved metals by USEPA Method 6010 (aluminum, antimony, barium, beryllium, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, silver, titanium, vanadium and zinc), 7421 (lead), 7470 (mercury), 7841 (thallium), and 7196 (hexavalent chromium). The only exception was arsenic and selenium, in which Standard Methods for Examination of Water and Wastewater, Method No. 3114B was utilized.
- Field test kits manufactured by Hach, Inc., were utilized to analyze select parameters (dissolved iron, D.O. and hydrogen sulfide). Ground water for the test kit analyses was collected using a disposable bailer using standard ground water sampling procedures (SOP Section 10 of the QAPP). Field tests were conducted immediately after ground water purging as per the manufacturers' specifications and the results recorded on the field ground water purging data sheets.
- Additional field parameters were collected using a YSI 6000 Water Quality Transmitter (YSI) unit, which included pH, dissolved oxygen, oxidation-reduction (redox) potential, specific conductivity and temperature.

2. Natural attenuation parameter analyses were performed during the July 1999 ground water sampling to assess whether natural degradation of the chlorinated hydrocarbons present in

ground water at the site is occurring. The resulting data may be used to support a future remedy or Corrective Measures Study to be conducted as part of ongoing Correction Action Process activities at the site. The natural attenuation parameters are summarized in the following bullets:

- Ground water quality parameters included total alkalinity, ammonia nitrogen, specific conductivity, dissolved organic carbon, ortho-phosphate, oxidation-reduction (redox) potential, pH and temperature.
 - Terminal electron acceptor parameters included dissolved oxygen (DO), nitrite/nitrate, total and dissolved iron, total and dissolved manganese, sulfate, hydrogen sulfide, carbon dioxide and methane.
 - Degradation products included chloride, ethane and ethene.
 - Technical quality control parameters included nitrogen (to determine whether atmospheric air has affected biogenic [produced by living organisms] gases) and propane/propene (potential indicator that methane concentrations are from a natural gas supply rather than biogenic methane).
3. The list of parameters does not include all parameters on DTSC's "Natural Attenuation" checklist. ARCADIS G&M reviewed DTSC's checklist and discussed with bioremediation experts and national laboratories regarding the applicability/usefulness of several of the parameters. After considering the benefits of each individual analysis on DTSC's checklist, ARCADIS G&M selected parameters which would provide the most useful information for evaluating degradation activity at this site. With the exception of hydrogen, the list of parameters selected does include those identified in the U.S. EPA *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*, September 1998 (USEPA 1998).
4. The ground water samples collected from the former ILM facility and the BRC property were analyzed for the above water quality, VOC, TPH, metal, and natural attenuation parameters. A sample was not collected from Well P-5 due to the presence of a petroleum hydrocarbon sheen and, therefore, analyses were not performed. A sample was not collected from Well P-12 because it was obstructed with debris and/or soil from recent site development activities.

4.2.2.1.5 Quality Control Sampling

1. To verify laboratory results, one duplicate sample was collected from the former ILM facility (at Well P-20), and one from the BRC property (at Well BL-6). Six equipment rinsate samples were collected to verify decontamination procedures; laboratory-grade, organic-free water was poured on a decontaminated sampler and into certified-clean sample bottles.

In addition, four field blank samples were collected to verify field sample handling and laboratory quality assurance/quality control procedures. Trip blanks supplied by the laboratory, accompanied each sample cooler containing samples for VOC analyses. A total of six trip blanks were analyzed.

2. Quality control samples were documented according to chain-of-custody protocol, placed in an ice-chilled cooler, and picked up by a courier on the same day and delivered to BC Laboratories in Bakersfield, California. Equipment rinsate samples and trip blanks were analyzed for VOCs using EPA Method 8260.

4.2.2.1.6 Waste Disposal

1. Wastewater generated from ground water well purging and sampling activities was temporarily stored onsite in Department of Transportation (DOT)-approved 55-gallon drums pending offsite disposal. Transportation and disposal of the wastewater was handled by Belshire Environmental Services, Inc., located in Lake Forest, California. The wastewater, classified as RCRA Hazardous (D040), was removed from the site for transport to U.S. Filter Recovery Services, Inc., a waste disposal facility located in Los Angeles, California. The hazardous waste manifest is included in Appendix E of this report.

4.2.2.2 Sampling Methodology for Offsite Monitoring Wells

1. The eight temporary ground water monitoring wells at the BRC property were gauged and sampled according to the methodology described in Section 4.2.2.1. These wells were gauged and sampled on July 12 through 16, 1999.

4.2.2.3 Sampling Methodology for Onsite Monitoring Wells

1. A total of 14 of the 15 existing wells at the former ILM property were gauged according to the methodology described in Section 4.2.2.1. Thirteen of those wells were sampled according to the methodology described in Section 4.2.2.1. These wells were gauged and sampled on July 12 through 16, 1999. Well P-5 was not sampled due to the presence of a petroleum hydrocarbon sheen and Well P-12 was not gauged or sampled because it was obstructed with debris and/or soil.

4.2.3 GROUND WATER MONITORING RESULTS

1. Ground water gauging, purging, and analysis results are discussed in the following sections. These results are summarized in Tables 4.2 through 4.15. Tables 4.2, 4.4, 4.6, 4.8, 4.10, 4.12 and 4.14 include results from activities conducted at the former ILM facility; Tables 4.3, 4.5, 4.7, 4.9, 4.11, 4.13 and 4.15 include results from activities conducted at the BRC property.

4.2.3.1 Ground Water Elevations and Flow Direction

1. Ground water elevations at the former ILM facility ranged from -8.24 to -14.15 feet relative to mean sea level (ft msl) (Table 4.2). Ground water elevations at the BRC property ranged from -12.38 to -14.43 ft msl (Table 4.3). The overall direction of ground water flow is towards the east-southeast across both properties. A map showing contours of equal ground water elevation for the July 1999 sampling event is provided in Figure 4.4.
2. Between August 1994 and July 1999, an overall increase in ground water surface elevation occurred beneath the former ILM facility (see Table 4.2 and ground water elevation contours in Figures 4.2, 4.3 and 4.4). Changes in ground water elevation ranged between +1.79 (Well P-3) and +4.76 (Well P-5) during this time period. Hydrographs for the former ILM facility wells are included in Appendix E. Overall, the general direction of ground water flow remained relatively unchanged (easterly in the western portion of the site and transitioning to the south/southeast on the eastern portion). The July 1999 average site ground water gradient, as calculated between Wells P-2 and P-7, was approximately 0.003 foot of vertical displacement per horizontal foot (ft/ft). There was relatively little change in ground water gradient from the March 1999 sampling event versus the July 1999 event.

4.2.3.2 Field Observations And Results

1. Between July 12 and 16, 1999, 13 ground water wells at the former ILM facility were purged prior to ground water sampling (two wells, P-5 and P-12, were not purged or sampled due to the presence of a petroleum hydrocarbon sheen and plugging, respectively). At least four well casing volumes were purged from 11 wells; the remaining two wells (Wells P-2 and P-24) were purged dry because the recharge rate was too low to maintain water in the wells during purging. During purging activities, measurements for temperature, pH, electrical conductivity, and turbidity were collected, and the color of the purge water was recorded for approximately each well volume purged. These parameters were measured as described in

Section 4.8.1 of the QAPP (Geraghty & Miller, 1996c [Appendix D]). In addition, dissolved oxygen, redox potential, dissolved iron and hydrogen sulfide were also collected in the field. Ground water well purging data sheets, which include records of the field measurements, are presented in Appendix G. The field measurements, including historical measurements, are tabulated in Tables 4.4 and 4.14.

2. For July 1999, the final ground water temperature in the 13 wells was between 22.8 degrees Centigrade (° C) (Well P-24) and 24.6 °C (Well P-25). The final pH reading for ground water ranged between 7.09 (Well P-22) and 7.62 (Well P-6B). The final conductivity reading ranged between 1,393 micromhos per centimeter (µmhos/cm) (Well P-7) and 4,010 µmhos/cm (Well P-2). Final turbidity readings were between 0 and 10 Nephelometric Turbidity Units (NTUs) in six wells and exceeded 10 NTUs in the remaining seven wells, with a maximum NTU of 630 in Well P-24.
3. At the BRC property, all eight wells were purged of three casing volumes of ground water prior to sampling. During purging activities, measurements for temperature, pH, electrical conductivity, turbidity, dissolved oxygen, oxidation and reduction potential, dissolved iron and hydrogen sulfide, were collected, and the color of the purge water was recorded for approximately each well volume purged. Ground water well purging data sheets, which include records of the field measurements, are presented in Appendix G. The field measurements are tabulated in Tables 4.5 and 4.15.
4. The BRC property wells exhibited similar temperature and pH field results as those of the former ILM facility wells, and slightly different overall conductivity and turbidity results. The final temperature ranged from 22.2° C (Well BL-6) to 23.9° C (Well BL-1). The final pH reading for ground water ranged between 6.92 (Well BL-1) and 7.48 (Well BL-7). The final conductivity reading ranged between 596 µmhos/cm (Well BL-4) and 4,060 µmhos/cm (Well BL-3). Final turbidity readings were between 10 and 100 NTUs in three wells and exceeded 100 NTUs in the remaining five wells, with a maximum NTU of 298.33 in Well BL-1.

4.2.3.3 Ground Water Chemical Analyses (Field And Laboratory)

1. After purging, the ground water wells were allowed to recharge to at least 80 percent of the original water column before sampling. Fourteen ground water samples were collected from

the former ILM facility, which included one duplicate sample from Well P-20. Nine ground water samples were collected from the BRC property, which included one duplicate sample from Well BL-6. Figure 4.1 shows the well locations.

2. No sample was collected from Well P-5 because a petroleum hydrocarbon sheen was detected in the well during water-level measurement activities. Also, a sample was not collected from Well P-12 because it was damaged. The Well P-12 casing was bent approximately 5 feet below ground surface by a construction contractor and an unknown blockage was present in the well at approximately 65 feet below ground surface. The damage is believed to have been caused by the contractor during installation of an underground utility line along the northern boundary of the site, immediately adjacent to Well P-12.
3. Although the sample from Well P-16C was analyzed for the same compounds as the other wells and the data were included in the tables and figures of ground water results, the analytical results were not utilized in assessment of the horizontal limits of ground water impacts. This is because Well P-16C, by design, was slotted at a deeper interval than the other wells in the Bellflower aquiclude water-bearing zone. The results were utilized in assessment of the vertical ground water impacts in Chapter 5.0.
4. Results of laboratory analyses of the ground water samples are discussed in the following sections. Summary results of ground water analyses, which exclude analytes not detected in any of the samples, are found in Tables 4.6 through 4.15. Appendix G contains copies of ground water well purging data sheets, chain-of-custody forms and daily logs for each ground water well. Copies of analytical laboratory reports, chain-of-custody forms, and data validation reports are located in Appendix H.

4.2.3.3.1 Volatile Organic Compounds (VOCs)

1. At the former ILM facility, 10 VOCs were detected above their PQLs in the 13 wells sampled in July 1999. TCE was the most frequently detected VOC; detected in 13 of 14 samples analyzed (includes one duplicate). Of the VOCs detected, TCE was also the highest in concentration, ranging between 3.2 micrograms per liter ($\mu\text{g/L}$) (Well P-10) and 10,000 $\mu\text{g/L}$ (Well P-1). (Graphs showing historical trends in TCE concentrations in each existing and former well on the former ILM facility from 1995 to the present are included in Appendix I and indicate significant decreases over time.) Some VOCs which were detected in the March

1999 sampling event, were not detected in the July 1999 event, possibly due to higher detection limits. The current and historical VOC concentrations in onsite wells are summarized in Table 4.6.

2. At the BRC property, VOCs which were the same or similar to those detected on the former ILM site were detected above their PQLs in the eight wells sampled in July 1999. TCE was again the most frequently detected VOC compound; it was detected in each of the nine samples analyzed (includes one duplicate). Of the VOCs detected, TCE was also the highest in concentration, ranging between 2.7 µg/L (Well BL-5) and 5,600 µg/L (Well BL-6). The March and July 1999 VOC results for the BRC property wells are summarized in Table 4.7.
3. Other than TCE, notable VOC analytes detected in ground water samples collected from the former ILM facility and BRC property in July 1999 include benzene, carbon tetrachloride, chloroform, 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, 1,1,1-TCA, toluene and vinyl chloride. Of these VOCs, benzene, carbon tetrachloride, trans-1,2-DCE, and toluene were not detected in the former ILM facility wells; and 1,1,1-TCA and vinyl chloride were not detected in the BRC property wells. The detection of 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride in July 1999 could be a result of degradation of PCE, TCE and 1,1,1-TCA. Chloroform, a common laboratory contaminant and degradation product of carbon tetrachloride, was detected at a maximum concentration of 10 µg/L (Well P-7). Benzene was detected in one offsite well (Well BL-5) at a concentration of 0.52 µg/L; toluene was detected in one offsite well (Well BL-3) at a concentration of 25 µg/L.

4.2.3.3.2 Total Petroleum Hydrocarbons (TPHs)

1. At the former ILM facility, ground water samples from 13 wells were analyzed for TPHs. TPHs were detected in four wells during July 1999. TPHs as diesel (TPH-d) were detected in Well P-2 at a concentration of 490 µg/L. TPHs as crude/waste oil were detected in Wells P-2, P-9B, P-16C and P-24 at 1,800, 1,400, 1,200 and 1,500 µg/L, respectively. TPH-d was also detected previously in ground water samples from Well P-5, but ground water from that well was not sampled in July 1999 because a petroleum hydrocarbon sheen was encountered during water-level measurement activities. TPHs as kerosene/jet fuel (TPH-k) has decreased in Well P-2 from 20,000 µg/L in July 1997, to 2,300 µg/L in March 1999, and then to ND in July 1999. TPH as crude/waste oil has also decreased in Well P-2 from 11,000 µg/L in March 1996 to 1,800 µg/L in July 1999. TPH-k and z-oil (a water-soluble hydraulic oil used during former operations at the ILM facility) were

not detected in the former ILM facility wells in July 1999. The number of wells with detectable concentrations of TPHs has remained approximately the same since the March 1999 sampling event. A summary of ground water analytical results for TPHs at the former ILM facility is presented in Table 4.8.

2. At the BRC property, eight monitoring wells were tested for TPHs. TPH-d was detected in two wells in concentrations ranging from 1,300 µg/L (Well BL-1) to 1,700 µg/L (Well BL-5). TPH-k, TPHs as crude/waste oil, and TPHs as z-oil were not detected in the samples from the BRC property wells. A summary of TPH analytical results for the BRC property wells is included in Table 4.9.

4.2.3.3.3 Metals

1. Ground water samples were analyzed for dissolved and total metals during the July 1999 sampling event. These metals included the 18 California Code of Regulation (CCR) Title 22 metals along with aluminum, iron, magnesium, manganese, and titanium. A summary of ground water analytical results for dissolved metals, including hexavalent chromium, is included in Tables 4.10 and 4.11 for the former ILM facility and the BRC property, respectively. A summary of results for total metals is included in Tables 4.12 and 4.13 for the former ILM facility and the BRC property, respectively.
2. At the former ILM facility, 15 total (arsenic, selenium, aluminum, barium, cadmium, chromium, cobalt, iron, lead, molybdenum, manganese, titanium, zinc, copper, and vanadium) and 8 dissolved (arsenic, selenium, barium, chromium, manganese, zinc, hexavalent chromium, and vanadium) metals were detected. Total aluminum was detected in ground water samples from the 13 wells tested. Dissolved aluminum, however, was not detected in the 13 samples analyzed. This pattern of aluminum detection continues a trend which is noted in previous sampling events, and which is most likely due to both the turbidity of samples and the natural background concentrations of aluminum in clays (Geraghty & Miller, 1996d, e and g). Total lead was detected in four ground water samples; dissolved lead was not detected in the samples. Dissolved hexavalent chromium was detected in 12 ground water samples (including one duplicate). Total and dissolved chromium were detected at similar concentrations to dissolved hexavalent chromium in the 12 samples, indicating the chromium is present as predominantly hexavalent chromium. Dissolved total and hexavalent chromium in Well P-1 exceeded the primary MCL of 0.05 mg/L. Dissolved manganese in Wells P-2, P-6B, P-7, and P-24 exceeded the secondary MCL of 0.05 mg/L.

3. At the BRC property, 16 total (arsenic, selenium, aluminum, barium, cadmium, chromium, cobalt, iron, lead, molybdenum, nickel, titanium, zinc, copper, vanadium and mercury) and 5 dissolved (arsenic, barium, chromium, manganese and hexavalent chromium) metals were detected. Total aluminum was detected in all nine ground water samples tested for aluminum (including one duplicate). Dissolved aluminum was not detected in the samples. Total lead was detected in all nine samples (including one duplicate); however, dissolved lead was not detected in any of the samples. Dissolved hexavalent chromium was detected in six samples (including one duplicate). Total dissolved chromium was detected at similar concentrations to dissolved hexavalent chromium in most wells, indicating the dissolved total chromium was present primarily as hexavalent chromium. However, unlike the former ILM site results, total chromium concentrations were 10 to 20 times higher than dissolved total or hexavalent chromium. Dissolved total and hexavalent chromium in Well BL-6 exceeded the primary MCL of 0.05 mg/L.
4. Total aluminum levels in ground water may be closely related to concentrations of metals in the soil, as mentioned previously in this report. The average aluminum concentration in soil samples collected at the site was 11,120 milligrams per kilogram (mg/kg) with a maximum detected concentration of 26,500 mg/kg (Geraghty & Miller, 1996d, e and g). Typical natural total aluminum concentrations in soil range from 10,000 to 300,000 mg/kg. Typical natural total aluminum concentrations in ground water range from <5.0 to 1,000 mg/L (i.e., <5,000 µg/L to 1,000,000 µg/L), *The Soil Chemistry of Hazardous Materials*, The Hazardous Materials Control Research Institute, 1988 (Dragun, 1988). Concentrations of aluminum in soil and ground water at the former ILM facility site fall within these typical natural concentration ranges.
5. Hexavalent chromium, detected in 12 ground water samples at the former ILM facility with July 1999 concentrations ranging between 2.0 µg/L (Well P-7) and 1,070 µg/L (Well P-1), was not detected in concentrations exceeding its PQL in soil samples collected during the Soil RFI activities, (Geraghty & Miller, 1997b). Hexavalent chromium was detected in six ground water samples (including one duplicate) at the BRC property, with July 1999 concentrations ranging between 10 µg/L (Well BL-4) to 214 µg/L (Well BL-6). Two soil samples at BRC property were analyzed for hexavalent chromium as part of the Offsite Well Installation program in early 1999; both contained concentrations of hexavalent chromium, at a maximum of 1,200 µg/kg.

4.2.3.3.4 Natural Attenuation Parameters

1. During the July 1999 sampling event, natural attenuation parameter data was collected to assess whether degradation of the chlorinated hydrocarbons present in ground water at the site and adjacent site is occurring. Specifically, data related to chemical and biological degradation were obtained from analysis of field and laboratory samples. The results for the former ILM facility and BRC property wells are summarized in the following sections. A summary of the degradation processes and parameter data evaluation is presented in Chapter 5.0.

General Ground Water Chemistry Parameters

1. Ground water chemistry parameters collected by field measurements included specific conductivity, redox potential, pH and temperature. Specific conductivity, pH and temperature results are summarized in Section 4.2.3.2 and included in Tables 4.4 and 4.5. The redox potential measurements ranged from -10.27 millivolts (mV) (Well P-2) to +348.73 mV (Well P-1) and are included in Tables 4.14 and 4.15. As electron acceptors and nutrients are depleted by microbial and/or chemical activity during degradation of contaminants, the redox potential of the contaminated aquifer decreases.
2. Ground water chemistry parameters obtained by laboratory analysis of samples included alkalinity, ammonia nitrogen, dissolved organic carbon and ortho-phosphate. The results for these parameters are included in Tables 4.14 and 4.15. Alkalinity results ranged from 213 mg/L (Well P-16C) to 654 mg/L (Well P-3). An increase in the alkalinity of ground water above background may be produced when carbon dioxide, released by biological activity, reacts with carbonate minerals in the aquifer matrix material. Ammonia nitrogen results ranged from nondetect (Wells P-1, P-3, P-9B, P-10, P-16A, P-16C, P-17, P-22, BL-2, BL-3, BL-4, BL-6 and BL-7) to 0.46 mg/L (Well P-2). In soil and ground water, oxidation and reduction of nitrogen species is accomplished by microorganisms. Dissolved organic carbon results ranged from 1.4 mg/L (Well BL-6) to 15 mg/L (Well BL-1). Dissolved organic carbon levels can differentiate background from anthropogenic (man-made) sources. Ortho-phosphate results ranged from nondetect (Well P-2) to 4.7 mg/L (Well P-16A). Phosphate is a nutrient with variable impacts on metabolic activity.

Terminal Electron Acceptor Parameters

1. Terminal electron acceptor parameters included dissolved oxygen, nitrite/nitrate, total and dissolved iron, total and dissolved manganese, sulfate, hydrogen sulfide, carbon dioxide

and methane. Dissolved iron and hydrogen sulfide were measured in the field, dissolved oxygen was measured both in the field and in the laboratory, with the remaining parameters analyzed in the laboratory. The results for these parameters are included in Tables 4.14 and 4.15.

2. Dissolved oxygen field results ranged from 3.0 percent saturation (Well P-2) to 89.8 percent saturation (Well BL-7). Dissolved oxygen laboratory results ranged from 0.52 mg/L (Well BL-1) to 7.47 mg/L (Well BL-7). The elevated dissolved oxygen concentrations detected in a majority of the ground water samples analyzed would suggest the samples were agitated during sampling or during preparation for analysis. This agitation will yield artificially high dissolved oxygen results. Nitrite/nitrate results ranged from 1.9 mg/L (Well P-24) to 15 mg/L (Well P-20).
3. Total iron concentrations ranges from 0.69 mg/L (Well P-22) to 431 mg/L (Well BL-6). The dissolved iron analyses were performed in the field and dissolved iron was detected in only one well (P-2) at a concentration of 1.0 mg/L. Based on the review of the dissolved iron measurements (non detect except one measurement at 1.0 mg/L [Well P-2]) and considering the measurements were performed in the field, the data was considered qualitative. Total manganese results ranged from 0.017 mg/L (Well P-3) to 7.49 mg/L (Well BL-6). Dissolved manganese results ranged from nondetect (Wells P-1, P-3, P-9B, P-16A, P-16C, P-20, P-22, BL-2, BL-4, BL-6, BL-7 and BL-8) to 1,440 µg/L (Well P-2).
4. Sulfate results ranged from 7.7 mg/L (Well BL-5) to 427 mg/L (Well P-2). The hydrogen sulfide analysis was performed in the field and the result was nondetect for each well. Based on the review of the hydrogen sulfide measurements (all nondetects) and considering the method utilized in the field, the data was considered qualitative. Field methods for measuring hydrogen sulfide in ground water which do not acidify the sample may not yield an accurate hydrogen sulfide reading. In addition, the DTSC natural attenuation checklist recommends a laboratory sulfide analysis method.
5. Carbon dioxide results ranged from 15.35 mg/L (Well BL-4) to 150.61 mg/L (Well BL-1). Carbon dioxide is a primary byproduct of the biodegradation of organic carbon under aerobic conditions. Methane results ranged from 0.086 µg/L (Well P-7) to 82.54 µg/L (Well P-24). Methane is a primary byproduct of the biodegradation of organic carbon under anaerobic conditions.

Degradation Product Parameters

1. Degradation product parameters included chloride, ethane and ethene. The results are included in Tables 4.14 and 4.15.
2. Chloride results ranged from 44 mg/L (Well BL-4) to 1,140 mg/L (Well BL-3). During biological or chemical degradation of chlorinated hydrocarbons dissolved in ground water, chloride is released into the ground water. Chloride concentrations in ground water contaminant plumes above background levels can be an indication of chlorinated hydrocarbon degradation.
3. Ethane results ranged from nondetect (Wells P-3, P-7, P-9B, P-10, P-16C, BL-1, BL-2, BL-4, BL-7 and BL-8) to 417 nanograms per liter (ng/L) (Well P-2). Ethene results ranged from nondetect (Wells P-3, P-7, P-16A, P-17 and P-22) to 104 ng/L (Well P-24). Ethane and ethene are the byproducts of the degradation of halogenated ethane and ethene compounds. The presence of ethane and ethene in contaminant plumes, therefore, indicates degradation may be taking place.

Technical Quality Control Data

1. Technical quality control data parameters included nitrogen and propane/propene. The results are included in Tables 4.14 and 4.15.
2. Nitrogen results ranged from 13.26 mg/L (Well BL-1) to 20.65 mg/L (Well P-16C). The nitrogen results are significant relative to the ammonia nitrogen and nitrite/nitrate results. In addition, this analysis can determine whether atmospheric air has affected biogenic gases. Propane/propene results ranged from nondetect (Wells P-3, P-9B, P-10, P-16C, BL-2, BL-4, BL-5, BL-6, BL-7 and BL-8) to 502 ng/L (Well P-2). Propane and propene do not typically occur in soils or ground water and their presence implies an anthropogenic contaminant source (e.g., petroleum hydrocarbon pipelines, underground storage tanks, oil or gas production wells, etc.). In addition, propane and propene are potential indicators that methane sources are from a natural gas supply rather than biogenic processes.

4.2.3.4 QA/QC Evaluation

1. Data Quality Objectives (DQOs) for July 1999 ground water monitoring were established so that high quality, legally defensible data was collected. QA/QC procedures are described in the QAPP and update (Geraghty & Miller, 1996c [Appendix D] & ARCADIS G&M, 1999d). These procedures were implemented by ARCADIS G&M during the July 1999 ground water monitoring activities and included field and laboratory QC as well as performance and systems audits.
2. DQOs are defined so that precision, accuracy, representativeness, comparability, completeness and sensitivity of analytical methods and associated data can be quantified and evaluated using standardized terminology for any project. Precision, accuracy and completeness are technical DQOs that can be evaluated by using specific mathematical formulas. Representativeness, comparability and sensitivity are DQOs that address the appropriateness of workplans, investigation strategies and laboratory methods. The final assessment and documentation of DQOs, and whether or not they are met, are end products of a field investigation, and are typically addressed in the data validation and data evaluation process. The following is a summary of the data validation evaluation for the July 1999 ground water monitoring analytical results.

4.2.3.4.1 Summary of the Data Validation Evaluation

1. Data validation qualifiers were applied to 21 of approximately 2,400 analytical results (approximately 1 percent) from 23 ground water samples, along with two duplicate samples, during the data validation process. The qualifiers are described in detail in the Data Validation Checklist, included in the back of Appendix H. The flagged results were determined to be estimated and detected ("J") for 14 results, not detected ("U") for five results, or unusable/rejected ("R") for two results. Overall, the performance on the analysis methods were deemed acceptable.
2. Performance on the inorganic metals analysis methods was deemed acceptable. Reporting limits on samples requiring dilution due to matrix interference were adjusted accordingly. Results which were greater than the detection limit but less than the practical quantitation limit were qualified accordingly. Matrix spike and matrix spike duplicate (MS/MSD) results for aluminum (total) in four samples and titanium (total) in one sample were outside the acceptable control limits and qualified accordingly. This did not appear to have an impact on the

aluminum and titanium results for these samples. Field duplicate results for total and dissolved arsenic for Well BL-6 were qualified as unusable/rejected. A comparison of total versus dissolved metals was completed and the results were considered acceptable.

3. Performance on the inorganic wet chemistry analysis methods was deemed acceptable. As with the metals analysis, reporting limits on samples requiring dilution due to interference, results greater than the detection limit but less than the practical quantitation limit and results outside acceptable control limits were qualified accordingly. The field duplicate result for DOC for Well P-20 was qualified as estimated with a 59 percent relative percent difference (RPD).
4. Performance on the organic wet chemistry analysis methods was deemed acceptable. Each trip blank submitted for Method 8260/VOCs analysis had positive results for methylene chloride, which is a common laboratory contaminant. Methylene chloride results for associated samples were less than the reporting limit and no further action was necessary. The surrogate recovery for Well P-2 was outside the acceptable control limits for 4-bromofluorobenzene. Detected results were qualified as estimated and no action was taken for results below the reporting limit. Reporting limits on samples requiring dilution due to interference, results greater than the detection limit but less than the practical quantitation limit and field duplicate results were qualified and deemed acceptable.

4.3 EVALUATION OF DATA QUALITY AND QA/QC PROGRAM

1. The ground water data contained in the prior ground water investigation reports were reviewed in accordance with the approved GWRFI QAPP (Geraghty & Miller, 1996c [Appendix D] and ARCADIS G&M, 1999d & 1999e) and the EPA National Functional Guidelines dated February 1994 for the review of inorganic and organic data. A data validation checklist was completed for each data set which included a review of field data package documentation, analytical data package evaluation and the inorganic and organic analyses. Data validation evaluations for the prior ground water investigations are included in the reports identified in Section 4.1. The data validation evaluation for the July 1999 sampling is included in this report in Section 4.2.3.4. A summary of the data validation checklist items and/or information and results is presented in the following paragraphs.
2. The field data package documentation review included the following items and/or information:
 - Sampling dates.
 - Sampling team.

- Sampling identification traceable to location collected.
 - Sample location.
 - Collection technique (bailer, pump, etc.)
 - Field sample preparation techniques.
 - Sample type (grab, composite).
 - Sample container type.
 - Preservation methods.
 - Chain-of-custody form completed.
 - Required analytical methods requested.
 - Field sample logs completed properly and signed.
 - Number and type of field QC samples collected (blanks, replicates, splits, etc.).
 - Field equipment calibration.
 - Field equipment decontamination.
 - Sample shipping.
 - Laboratory task orders.
3. The analytical data package documentation review included the following items and/or data:
- Sample results.
 - Parameters analyzed.
 - Method of analysis.
 - Reporting limits of analysis.
 - Master tracking list.
 - Sample collection date.
 - Laboratory sample received date.
 - Sample preparation/extraction date.
 - Sample analysis date.
 - Copy of chain-of-custody form signed by lab sample custodian.
 - Narrative summary of QA or sample problems.
4. The review of the analytical results included the following items and/or data:
- Hold times (extraction and analysis).
 - Reporting limits.
 - Blank preparation and results (instrument, extraction, equipment, field and trip).
 - Matrix spike/matrix spike duplicate results.
 - Laboratory duplicate results.
 - Field duplicate results.
 - Laboratory control sample results.
 - Surrogate spike recoveries.
 - Reagent water spike recoveries.
 - Total and dissolved metals result comparison.
5. Based on the results of each data validation checklist reviewed, the data was deemed acceptable. Only a small percentage of the data required qualification (e.g., qualified data accounted for approximately 1 percent of the total data). Typical data qualifiers included U (not detected), J (estimated, detected) and R (unusable, rejected). The qualified data was

evaluated accordingly (e.g., the data was limited in its use or not utilized) in assessing the limits of ground water impacts and the overall results. Major or significant problems which would qualify the ground water data were not encountered or identified.

6. The data quality presented in this GWRFI report complies with the QA/QC requirements deemed acceptable pursuant to the GWRFI QAPP and EPA guidelines established for performance of an RFI. The data, therefore, can be utilized with a high degree of confidence in evaluating and determining the limits of ground water impacts.